Global Journal of Engineering Education

Engineering education as a second career: the experience of female practising engineers

Luis M. Dos Santos

Woosong University
Daejeon, Republic of Korea

ABSTRACT: Both the science, technology, engineering and mathematics (STEM) industries and the education profession are facing a human resource shortage, particularly in STEM university-level education. Many engineering institutions and departments are seeking engineering educators with practising experience, who in the classroom can transfer their industrial experience to potential engineers. Given the engineering industry is considered to be male-dominated, where female professionals are a minority, female engineering educators are even harder to recruit. The purpose of this study was a) to understand why female practising engineers switch careers, away from the industry to the teaching profession, and b) how do females describe their engineering educator experiences within the East Asian region. The research produced significant insight into the human resource shortage in engineering, particularly on how gender, finance, environmental impact and personal agencies influence female engineering educators' career decisions.

Keywords: STEM, engineering educators, female engineering educators, career decisions, human resource shortage

INTRODUCTION

At present, both the science, technology, engineering and mathematics (STEM) industries and the education profession are facing a human resource shortage [1]. Although fresh graduates and junior professionals in STEM may fill some of the gaps of the workforce, the numbers of junior professionals may mean there are significant shortages [2].

The STEM field largely is considered a male-dominated industry of which female professionals make up a small proportion. However, the skills and abilities of female professionals are at the same level as male professionals [3]. Therefore, the purpose of this study was to examine the reasons and factors influencing the decision to become an engineering educator as a second career at university level in China, particularly among female engineering professionals.

Economic and technological development in the East Asian region has led to the engineering industry requiring experienced engineers, as well as educators, for the next generation. These human resource challenges are not exclusive to the STEM industry; STEM education, particularly engineering education, also has the same issue, as a result of career development, salary and compensation [4].

However, current data on engineering education and second-career teachers in engineering indicates there is little to attract and to motivate professional engineers to switch careers, from engineering to engineering education [5]. As the shortage of practising engineers is already significant, education in engineering faces an even stronger challenge. There are four major reasons for the shortage. These are:

- Both undergraduate and postgraduate STEM programmes, particularly engineering programmes, lack any form of teacher training or information for trainers and instructors in the field [6]. Therefore, most of the fresh graduates enter the practising field after the completion of their academic training at university [7].
- Salary and compensation for those working in STEM education programmes, particularly in engineering, at both secondary and tertiary levels are not as attractive as when practising. As a result, most mid- and senior-level engineering professionals tend to stay in their positions instead of switching to teaching [8].
- Staff vacancies in STEM education programmes, particularly in engineering, are far fewer than those in the practising field, giving few opportunities for mid- and senior-level practising professionals to join the teaching

profession. Furthermore, most university vacancies require at least a doctoral degree and post-doctoral experience. Practising professionals may not meet these requirements for teaching opportunities [9].
- For female STEM educators, particularly in engineering education, they are in a minority. Therefore, there must be far fewer female educators than there are male professionals [10].

There is some research on the decisions of engineering educators beginning their teaching career following the completion of post-doctoral training [11]. However, there is little research on the transition of professional engineers into engineering education, particularly for female engineers. If potential second-career teachers lack confidence or self-efficacy in teaching, there is a tendency to stay in their original line of work, which may offer better career prospects.

Although there is postgraduate training for second-career teachers, most of these programmes tend to be for K12 teachers, such as the Postgraduate Certificate in Education, and Master of Teaching (elementary and secondary) programmes. None of these training programmes focuses on providing second-career training for instructors at university level [12].

Indications from literature suggest that professionals practising in industry often find it difficult to manage teaching materials, teaching and learning strategies, mentorship, time management, and classroom management [13]. Although some professionals may be invited for guest lecturing, most practising professionals do not have enough training to teach the standardised 16-week modules for both traditional and evening students.

Some research has also indicated that gender could be a prohibitive factor in applying for university programmes, such as elementary school teaching, nursing, engineering, military, railroad or architecture [14]. Although gender is not a factor in switching career and for career development, elementary school teaching tends to be a female-dominated profession, with fewer male teachers. Similarly, in STEM, particularly in engineering, there tends to be more male than female professionals. Therefore, an understanding of how to attract female practising professionals to the teaching profession is one of the most important issues in the present environment [15].

Research: the Background

The metropolitan region in eastern China was selected for investigation. First, unlike other East Asian countries, such as Japan and Korea, the rights and acceptance in the workplace of female professionals is largely the same as for male professionals. In other words, there is less expectation for women to stay at home as housewives after marriage and university graduation. Although housewifery is one of the most popular occupations among Chinese women, there is also an understanding of their rights and options in career development.

Second, unlike other regions in western and rural China, the eastern Chinese metropolitan area is one of the most populated regions, as well as being a scientific hub with a large number of research-based universities and high-level technology organisations, which may attract potential second-career teachers in engineering education at university level. Therefore, the experience of successfully switching careers in this region may give useful information as to how practising engineers switch careers to teaching, particularly female practising engineers and engineering educators.

The present qualitative study deals with second-career teachers in engineering education, who have at least 10 years of work experience in engineering, both nationally and internationally. These participants already have completed their Master or doctoral degree in engineering and have switched their career to teaching at one of the universities in the eastern Chinese region. The purpose of this research was to understand two points:

- Why do female practising engineers decide to switch career development from industry to the teaching profession?
- How do the participants describe their experience and difficulties as female engineering educators while they switched careers?

The current research was guided by the social cognitive career theory (SCCT) [16]. Bandura's social cognitive theory [17] was a blueprint for exploring how people learn and make sense of a particular process and how it affects their behaviour. The SCCT is useful in the present research for three reasons:

- The understanding, experience, establishment of career development and career-related interests.
- The decisions and motivation for switching from practising to teaching.
- Difficulties and self-efficacy of female engineers and engineering educators.

The SCCT highlights the impact of cultural, social and financial factors on individuals' self-understanding, and the outcome of opportunities. The disadvantages and shortages of the abovementioned factors could be interrelated and highly influenced by each other, with individuals affected by only one factor or all three factors [18].

In the case of female engineering educators, it is not hard to believe that female Chinese engineering educators might face difficulty, bias and discrimination in the classroom through cultural and social expectations of their gender.

Therefore, the researcher has used the SCCT to understand and explore the career decisions and issues faced by female engineering educators in the eastern Chinese region.

METHODOLOGY

A qualitative methodology with in-depth interviews was appropriate, because the goal of this research was to look closely at the understanding of female practising engineers who decided to switch careers to become engineering educators at university level in the eastern Chinese region [19].

Participants and Data Collection

Participants needed to meet the following eligibility conditions. First, they must have been employed (at the time of interview) in engineering as practising engineers for at least 10 years. Second, these participants must have completed their Master or doctoral degree in engineering. Third, the participants must have switched their careers, from practising to teaching at one of the universities in the eastern Chinese region.

The participants were notified that this research focused on career decisions and becoming second-career university instructors. The breakdown of their practising field and academic expertise was as follows: 1) architecture; 2) agriculture; 3) biomedicine; 4) civil engineering; 5) computers; 6) electronics; 7) energy; 8) materials; 9) mining; 10) molecular science; 11) petroleum; 12) railroad and transportation; 13) software; 14) textile; and 15) water resources. All participant names were anonymous.

Based on the literature review and research questions, two sessions of semi-structured one-to-one interviews were held. The researcher interviewed participants individually for between 60 to 90 minutes about their previous experience as practising engineers. Following this, the participants were invited for a second interview about their current experience as engineering educators and the reasons why they decided to switch career to university teaching. All conversations were recorded, transcribed and returned (i.e. member checking) to the participants for validation.

RESULTS AND FINDINGS

After 76 interview sessions, the researcher analysed the interview transcripts into meaningful themes and subthemes following a general inductive approach. Through this qualitative inquiry, the researcher conducted an inductive analysis of the data and established themes to answer the research questions and discuss the results. Analysis of the interviews yielded two themes and five subthemes. Quotations from interview transcripts supported the findings. Outlined in Table 1 are the themes and subthemes.

Table 1: Themes and subthemes.

Themes	Subthemes
Stable employment	Lighter working schedule: family and children
	Responsibilities
Meaningful and inspiring career	Knowledge transfer from practice to education
	Isolation and lack of support
	Encouraging more females to join STEM

Stable Employment

The findings of the research identified the theme of stable employment, which arose mainly from the first research question, asking why female practising engineers decided to switch their career from the engineering industry to the teaching profession.

Unlike fresh graduates and junior professionals, mid- and senior-level professionals had solid reasons for switching careers. All participants had worked in industry outside teaching (i.e. practising engineers). Within this primary theme of stable employment, the participants described experiencing events and instances as motivations for their employment. The two subthemes identified within this primary theme were: 1) lighter working schedule: family and children; and 2) responsibilities.

Lighter Working Schedule: Family and Children

All participants (N = 38) expressed that their practical engineering experience in the industry occupied most of their daily schedule, and they struggled to manage both families and work time. Two major issues were illuminated. First, because of the East Asian social and cultural perspective, women and mothers are the primary carers for their family and children. However, as most of the practising engineers needed to work with other commitments, all participants tended to resign from their position to seek a balance between work and family. For example, one

participant noted: *I need, not only want, to leave my career… perhaps switch my career direction from practising engineering to others as I need to take care of my child* (Participant #6, biomedical).

It is worth noting that the words family and children appeared more than 800 times within the transcripts. Therefore, most of the participants decided to switch careers from practising engineering to engineering education, because of their commitments to family and children. This was particularly the case for women for whom family is the priority.

Second, besides the commitments of their own families and children, all participants expressed their concerns about their in-laws and maternal families. The cultural and social expectations of East Asian people require most families in China to take care of their in-laws and maternal families. In other words, married women need to take care of their parents and their in-law parents, as well. One extreme case pointed out: *Combining job, families, in-law families, maternal families, and children's work, as a daughter, mother, wife, and daughter-in-law… I cannot handle and stand it anymore* (Participant #29, computers).

Responsibilities

The responsibilities and commitments in practising engineering and of engineering education is another important factor highlighted by the interviews. Unlike other office positions, the practising engineer's duties involve considerable field work, outdoor activities and international conferences. Such extensive activities impact not only on female practising engineers, but also on parents and male professionals with family responsibilities. A participant noted: *Most of the mines are located in the western regions of China … but my parents and families are living in the eastern region … I do not want to live four hours' flight away from my loves* (Participant #37, mining).

Another participant highlighted a similar situation in which she needs to attend international conferences every other week: *China is working with many African and eastern European countries. I need to go to these regions for meetings every other week … I cannot see my child at all* (Participant #12, software).

In short, although not exclusively, most of the participants shared similar stories and situations arising from the responsibilities of their career development. It is worth noting that female professionals tended to believe that stable employment could provide a balance between career development and family. Common to all were the cultural and social considerations of Chinese expectations. However, as engineering educators, stable employment and schedule offered more time for other interests.

Meaningful and Inspiring Career

This theme arose mainly from the second research question that asked how participants understood and would describe their experiences and difficulties as female engineering educators during the period of switching careers. Although the financial incentives of the teaching profession are not as attractive as those in engineering practice, the participants expressed that money and salary were not the primary reason for switching career. Within this second theme of a meaningful and inspiring career, participants described experiencing positive and negative events and instances as motivations for their employment. The three subthemes identified within this second theme were: 1) knowledge transfer from practice to education; 2) isolation and lack of support; and 3) encouragement of more females to join the STEM field.

Knowledge Transfer from Practice to Education

All participants expressed that their industrial experience and practice could be highly beneficial to junior and potential engineers in university education and training. A major subtheme was identified as the transfer of knowledge from real-life cases to potential engineers, rather than simply relying on textbook cases, which may be less relevant to contemporary industry. For example, a participant gave an indication of how weather can impact the high-speed train system in China: *China is very large. In the winter, many of our high-speed trains need to operate from the northern freezing region to the tropical region in Hong Kong … the textbooks are about theories; how to manage such real-life situations is all about our experience* (Participants #28, railroad and transportation).

Many others also considered real-life case studies to be vital in teaching. This was echoed by a participant who pointed out: *The soil and landscape are not the same between regions in China … but the textbooks somehow employ one universal theory for teaching … I need to tell my students about these real case studies* (Participant #33, civil engineering).

Isolation and Lack of Support

More than 30 participants believed isolation was one of the difficulties in switching career. Unlike the teaching profession, the practising engineer is involved in interaction and co-ordination, because of the project-based nature of their work. In contrast, teaching can be a more isolated career. Many expressed that postgraduate training and learning did not equip them to deal with isolation, because most of the courses and lessons were involved with projects. For example, a participant

expressed a concern with her co-workers in the department: *We usually only have one or two faculty members with the same expertise in the department … I cannot ask for help from others* (Participants #2 materials).

Another participant expressed a similar point at her workplace: *Although we expected our students to have … training in interaction and engagement, engineering education is not the same … We somehow do not have any interactions between each other* (Participant #5, petroleum).

Another issue within this subtheme is the working environment in engineering education. Several participants said their co-workers tended to be academic-oriented experts, without fieldwork experience. Therefore, the teaching strategies and practices may not match the guidelines of other types of work. As one participant pointed out: *Co-workers tended to employ teacher-centred strategies, in which students tended to be the listeners … but when I requested some tools and equipment for student-centred activities, I could not* (Participant #14, textile).

Encouraging More Females to Join STEM

More than 30 participants believed their switching might encourage more female professionals to join STEM, particularly in encouraging potential secondary school graduates. Chinese cultural and social expectations have resulted in STEM, particularly in engineering, being dominated by male professionals. Although women may join the field and the university courses, social and cultural norms, as well as understanding, may impede motivation. These participants indicated a desire to serve as departmental representatives to connect the industries and secondary schools.

One participant expressed that her field requires more female professionals to increase diversity and communication: *Engineering is not only for men but for people with an interest. I want to encourage more girls to join us and the industry … my practising experience and communication could tell girls that engineering is for you* (Participant #15, molecular science).

Another participant, who at one time worked for a water resourcing company expressed the need for diversity: *Water resources are everywhere in the city, why should girls not join the industry? I want to be a representative to tell girls to enter the field … and I will share my stories with all the girls* (Participant #1, water resources).

The findings of this section are reflected in previous studies dealing mainly with the cultural, social and financial factors of career development, decisions and processes of female practising engineers and engineering educators. The interview transcripts illustrated the experiences of female engineers from practising to education. The researcher also found that, even though there are no prohibitions to women joining and studying engineering, cultural and social norms, and expectations in China still limit girls from entering the field. In particular, all participants believed family commitments limited their opportunities for career promotion and development as female professionals in China. Interestingly, the sense of family (both in-law and maternal family) was the most important factor in their lives. Therefore, as family responsibility and commitment are seen as a top priority, this would be the strongest motivation for switching career.

All participants expressed their goals in teaching the next generation by bringing their professional fieldwork and case studies into the university classroom. There were difficulties in becoming involved in teaching and learning, as university departments tended to employ academic teachers who had not worked in industry. However, participants felt their expertise could increase classroom diversity by highlighting female minority experience in industry. Significantly, the results of this research indicated the motivations and reasons as to why females practising engineering decided to switch mid-life careers to teaching.

CONCLUSION, IMPLICATION AND FUTURE DIRECTIONS

The completion of this research provides three significant insights into the human resource shortage in engineering (including engineering practice, engineering education and female employment in engineering). First, the research outlined the reasons and motivations of practising professionals in switching their careers to teaching. Although the research was targeted at female engineers, the results may reflect the experience of all STEM professionals with family responsibilities and engagements in the East Asian region.

Second, based on the SCCT guidelines, the research also indicated the cultural, social and financial factors influencing practising engineers in the teaching field. Although women's rights have increased within this century, female professionals in STEM still face discrimination and bias because of gender, cultural and social expectations in the East Asian region.

Finally, the results of this research provide direction for university administrators, governmental leaders, policymakers and human resource professionals to reform and improve current human resource planning by encouraging practising professionals to switch their careers to teaching. Although the research skills of university instructors are important in achieving scientific results, the voice and experience of practising professionals may also provide knowledge and practice for potential and fresh graduates. As engineering practice requires significant fieldwork experience and project-based activity, mid- and senior-level professionals may bring information regarding these practices into the classroom environment.

The geographic limitations of this research mean future studies may be focused on larger populations affected by this issue. For example, both Japan and Korea share cultural, social and financial similarities with China. Leadership in these countries may face the same problems and challenges, such as the shortage of STEM professionals in both practise and education. Future research may further extend the scope from engineering to other professionals within the STEM environment. Nevertheless, this research provides a general lens, which can help related professionals to reform and improve their planning and schemes in the immediate future.

ACKNOWLEDGEMENTS

This research study was supported by the funding from Woosong Academic Research Funding 2019.

REFERENCES

1. Dos Santos, L.M., Science lessons for non-science university undergraduate students: An application of visual-only video teaching strategy. *J. of Engng. Appl. Science*, 14, **1**, 308-311 (2019).
2. Weiner, L. and Jerome, D., *Urban Teaching: The Essentials*. (3rd Edn), New York, NY: Teachers College Press (2016).
3. Kamphorst, J.C., Adriaan-Hofman, W.H., Jansen, E. and Terlouw, C., Explaining academic success in engineering degree programs: do female and male students differ. *J. of Engng. Educ*., 104, **2**, 189-211 (2015).
4. Zeidler, D., STEM education: a deficit framework for the twenty first century? A sociocultural socioscientific response. *Cultural Studies of Science Educ*., 11, **1**, 11-26 (2016).
5. Reinhold, S., Holzberger, D. and Seidel, T., Encouraging a career in science: a research review of secondary schools' effects on students' STEM orientation. *Studies in Science Educ.*, 54, **1**, 69-103 (2018).
6. Rahman, E.K.A., Rahman, S.K.A., Nor, A.A.M., Tan, S.J., Yap, Y.H. and Zahran, E-S.M.M., Application of reflective papers in civil engineering education: a case study. *Global J. of Engng. Educ*., 21, **2**, 145-149 (2019).
7. Hanson, J., Paulsen, M. and Pascarella, E., Understanding graduate school aspirations: the effect of good teaching practices. *Higher Educ*., 71, **5**, 735-752 (2016).
8. McDonald, J. and Sorensen, J., Academic salary compression across disciplines and over time. *Economic Educ.* Rev., 59, 87-104 (2017).
9. Robinson, W., McGee, W., Bentley, L., Houston, S. and Botchway, K., Addressing negative racial and gendered experiences that discourage academic careers in engineering. *Computing in Science and Engng*., 18, **2**, 29-39 (2016).
10. Serranom M. and Groh, J., Travel grants which facilitate engineering leadership identity in female engineering students. *2016 IEEE Frontiers in Educ. Conf*., 1-4 (2016).
11. Bubbar, K., Dimopolous, A., Gaetz, R., Wild, P. and McWilliam, M., Evolution of the design engineering mentorship program. *Proc. Canadian Engng. Educ. Assoc. Conf.* (2017).
12. Mendez, S., Conley, V., Keith, R., Haynes, C. and Gerhardt, R., Mentorship in the engineering professoriate: exploring the role of social cognitive career theory. *Inter. J. of Mentor. and Coaching in Educ*., 6, **4**, 302-316 (2017).
13. Al-Junaid, H., Almeer, M., Khlaifat, J. and Bushager, A., Developing a computer engineering undergraduate curriculum: the challenges and solutions. *Global J. of Engng. Educ*., 21, **1**, 45-53 (2019).
14. Mlambo, Y. and Mabokela, R., It's more flexible: persistence of women engineers in the academy. *European J. of Engng. Educ*., 42, **3**, 271-285 (2017).
15. Pusca, D. and Northwood, D.O., Design thinking and its application to problem solving. *Global J. of Engng. Educ*., 20, **1**, 48-53 (2018).
16. Lent, R.W, Brown, S. and Hackett, G., Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *J. of Vocational Behavior*, 45, **1**, 79-122 (1994).
17. Bandura, A., Self-efficacy mechanism in human agency. *American Psychologist*, 37, **2**, 122-147 (1982).
18. Lent, R.W. and Brown, S.D., Social cognitive approach to career development: an overview. *Career Develop. Quarterly*, 44, **4**, 310-321 (1996).
19. Merriam, S.B., *Qualitative Research: a Guide to Design and Implementation*. San Francisco, CA: Jossey Bass (2009).

BIOGRAPHY

Luis Miguel Dos Santos at present is an Assistant Professor in the Woosong Language Institute at Woosong University, Republic of Korea. He received his Doctor of Education degree at Northeastern University in Boston, in the USA. His research interests include adult education, career decision, curriculum and instruction, educational studies, educational leadership, foreign language teaching and learning, gender studies, higher education administration, lived stories, qualitative research, teachers' professional development, secondary education, STEM education, as well as textbook evaluation. He has published more than 50 book chapters and peer-reviewed journal articles internationally.